Resonance Microwave Reflectometry for High-Resolution Surface Imaging

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Novel high-resolution near field imaging technique based on microwave resonance reflectometry is presented. Two types of microwave resonance probes are considered – a small helix antenna and a resonantly loaded aperture in conductive screen. It is shown that these probes possess the electromagnetic (EM) characteristics essential for high-resolution near field imaging device: (*i*) they enable very tight near field collimation with full width at half maximum less than $\lambda/10$, λ is a wavelength of radiation; (*ii*) the probes near field coupling to the imaged samples is based on the high-quality resonance energy transmission which allows their operation at very low excitation power level with high receive signal-to-noise ratio. Additionally, the resonance nature of these probes enables accurate microwave spectroscopic characterization of a wide range of dielectric materials. To the best of the authors' knowledge resonance microwave probes of considered types have never been applied to near field imaging before.

In the talk the second-to-none resolution properties of the proposed technique are demonstrated in various near field imaging scenarios involving conductive printed elements/printed antennas, dielectric structures, surface defects and biomaterials. Particularly, it is shown that the typical resolution contrast between the subwavelength metal and/or dielectric structures (for quarter-wavelength or smaller features) in raw reflection images is more than 10dB in amplitude and 100 degrees in phase over the range of standoff distances $\lambda/20$ - $\lambda/10$. For comparison, most existing near field probes based on the open-ended coaxial cables or open-ended waveguides exhibit prohibitively low resolution contrast, within ~1-2dB range.

A correlation-based image processing technique which permits detection of subwavelength defects (with characteristic size less that $\lambda/20$) with extremely high resolution contrast (more than 20dB) in periodic printed structures is also discussed and illustrated using experimental data.

Additionally, an artificial dielectric skin model is developed to show the potential of the proposed technique in early stage skin cancer identification. Highly accurate EM discrimination between malignant tumours, benign lesions and healthy skin based on the water content difference in cancerous and normal skin tissue can be performed using the proposed near field probes. To represent the EM properties of the cancer-affected skin, three types of lossy dielectric with different absorption level have been used to model malignant melanoma, healthy tissue and benign lesions. It has been shown that a malignant tumour with characteristic size $\lambda/10$ can be discriminated with at least 6dB amplitude and 50 degrees phase contrast from healthy skin and with more than 3dB contrast from a benign lesion of the same size. These results open up the possibility for highly accurate early-stage melanoma detection.